



Measurement of Deflators and Real Value Added in the Service Sector

Kyoji Fukao (Hitotsubashi University, Japan), Taisuke Kameda (Economic and Social Research Institute, Cabinet Office, Japan), Kota Nakamura (Economic and Social Research Institute, Cabinet Office, Japan), Masahiro Sato (Economic and Social Research Institute, Cabinet Office, Japan), and Ryoichi Namba (Economic and Social Research Institute, Cabinet Office, Japan)

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Kyoji Fukao

Hitotsubashi University

Taisuke Kameda

Economic and Social Research Institute, Cabinet Office, Government of Japan

Kota Nakamura

Economic and Social Research Institute, Cabinet Office, Government of Japan

Ryoichi Namba

Economic and Social Research Institute, Cabinet Office, Government of Japan

Masahiro Sato

Economic and Social Research Institute, Cabinet Office, Government of Japan

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Abstract

The estimation of output and prices in the service sector entails various theoretical and practical difficulties that are distinct from the challenges faced when examining the manufacturing sector. Some of these difficulties are due to the non-existence or limited functioning of the market mechanism in the sector, while others are due to certain economic characteristics of services, such as their intangibility and heterogeneity.

For instance, an area in which the estimation of output is particularly difficult is non-market services. For some publicly provided services, such as government-funded education, the absence of a market means that market prices are not available. For other services, such as medical care, relevant prices may be available, but using such prices may provide misleading valuations of output, since they do not reflect the value that consumers attach to such services, with the discrepancy arising, for example, as a result of asymmetric information or price regulation. However, even in the market sector, there are measurement issues with regard to certain services. An example is retail and wholesale services, for which it is difficult to construct margin price indexes due to the lack of publicly available information.

These difficulties, in turn, make cross-country comparisons of total factor productivity (TFP) growth, which greatly depend on how output and prices are calculated in each country, particularly problematic, since statistical agencies in different countries have adopted different approaches to address these difficulties. For instance, many countries have adopted an input-cost approach for the measurement of non-market services, but the range of service sector industries to which the approach is applied differs across countries. Moreover, some countries incorporate the quality of inputs, such as workers' educational attainment, into the calculation of input values, while other countries do not. Furthermore, some countries are shifting from the input-cost approach to the estimation of real output by incorporating quality adjustments (such as scholastic ability test results or survival rates) when measuring quantities (such as the number of graduates or patients).

This paper provides a comparison of approaches to the measurement of service sector deflators in Japan and other developed countries such as the United States in order to examine the potential impact of methodological differences on estimates of the macroeconomic performance of these countries. Specifically, for education and medical care services, we compare the range of industries to which the input-cost approach is applied and the way qualitative indicators are incorporated in the calculation of input costs and output values. For retail and wholesale services, we consider how the use of margin prices instead of the sale prices of products affects the estimated output of these two industries. Using these comparisons, we consider how differences in the measurement of deflators affect the measured TFP growth in the countries examined and, furthermore, consider the implications for future revisions of methods of measuring deflators.

1. Introduction

Numerous studies on Japan have shown that growth in service sector productivity has been sluggish and, moreover, that productivity is quite low compared to the United States and Europe (Inklaar and Timmer 2008, Fukao 2013, Jorgenson, Nomura and Samuels, forthcoming). Given that the service sector accounts for about 80 percent of Japan's GDP and employment, boosting service sector productivity plays a crucial role in raising economic growth and living standards.

Although a number of studies have sought to examine what is needed to raise Japan's service sector productivity (e.g., Fukao 2012, Morikawa 2014), these studies have to contend with severe data constraints. Measuring industry- and firm-level productivity growth requires data on changes in real output. Unfortunately, however, in Japan's System of National Accounts (SNA), for sectors such as public administration, large parts of education, construction, and social welfare, which together make up about a fifth of Japan's GDP, instead of real output indexes, factor input indexes are used, where nominal costs or nominal output are divided by price indexes of input factors. For this reason, productivity growth in these sectors by definition is more or less zero. Further, there are serious problems with regard to the deflators used for converting nominal into real output for sectors such as wholesale & retail and medical care, which make up about another fifth of GDP.¹

In recent years, initiatives to address measurement issues to examine service sector performance and devise policies to raise productivity growth have sprung up in many advanced countries. The OECD Statistics Directorate, for example, in 2010 released a manual on methods to construct real output statistics for medical care and education (Schreyer 2010, 2012, Schreyer and Mas 2013). The basic approach recommended in the manual when constructing real output indexes for public services for which the construction of price data is difficult is to avoid using factor inputs as a substitute and instead to include quality adjustments (such as scholastic ability test results or survival rates) when measuring quantities (such as the number of graduates or patients). Meanwhile, the SPINTAN (Smart Public Intangibles, 2013–16) project supported by the European Commission tries to find ways to accurately measure service quality and real output and use the results to examine the determinants of productivity and devise policies for raising productivity growth. In fact, various statistical agencies have already responded to such initiatives, with the UK's Office for National Statistics (ONS) creating output indexes and GDP statistics which, for a wide range of public services including education, take quality changes into account (ONS 2007). Similarly, the United States has adopted various measures to improve statistics with regard to commerce, construction, etc., while the OECD and Eurostat recently revised their guidelines for the construction of service producer price indexes (OECD/Eurostat 2014).

In contrast, in Japan, partly as a result of insufficient staff at statistical offices, there has been little progress in preparing and improving service sector statistics, so that Japan has started to fall

¹ Miwa (2014) discusses these issues in detail.

behind other advanced countries. In addition, in Japan, documentation on how quantities and prices are estimated for GDP statistics is much less detailed than in the United States and other countries. For instance, BEA (2015) provides a table extending over 16 pages that explains in detail how each personal consumption expenditure component is estimated, including descriptions of the estimation of quantities, prices, and expenditure in current dollars. In contrast, Japan’s Economy and Social Research Institute (ESRI), which is in charge of estimating Japan’s GDP statistics, does not provide such detailed tables in their handbook on GDP statistics (ESRI 2012).²

Against this background, one of the aims of this paper is to compare Japan’s methods of estimating service sector quantities and prices for GDP statistics with those employed in the United States and other developed countries. In particular, we focus on five sectors, namely, (1) construction, (2) wholesale and retail, (3) education, (4) health care, and (5) public administration and defense, compulsory social security, in which we think measurement problems are most serious. Taken together, these sectors account for a substantial share of the economy in Japan and elsewhere, as can be seen in Table 1, which presents the share of the five sectors in value added and labor input in the economy in Japan, the United States and the UK. The table indicates that in terms of gross value added, these five sectors account for about 35–40% of economic activity, while in terms of labor input they account for about 40–50%.

Table 1. Share of the Five Sectors in Value Added and Labor Input in the Economy: Japan, United States and UK Comparison

	Gross value added share in GDP			Man-hour input share in the total economy		
	US (2010)	UK (2010)	Japan (2012)	US (2010)	UK (2009)	Japan (2012)
Construction	3.6%	7.0%	6.1%	5.9%	8.2%	9.0%
Wholesale and retail	9.7%	10.8%	13.4%	13.5%	14.4%	14.4%
Education	5.9%	6.8%	3.5%	8.2%	6.9%	3.2%
Health care and social work	12.6%	8.1%	6.0%	17.9%	10.9%	10.6%
Public administration and defense, compulsory social security	4.2%	5.3%	9.3%	3.4%	5.7%	5.5%
Total	36.0%	37.9%	38.2%	48.9%	46.1%	42.7%

² Some additional information on deflators in Japan’s GDP statistics can be found in Yamanaka et al. (2013). Another potential source of information is the *Linked Input-Output Tables*. Every five years, the Statistics Bureau of the Ministry of Internal Affairs and Communications (MIAC) publishes the *Linked Input-Output Tables* (the most recent edition are the *1995-2000-2005 Linked Input-Output Tables*), in which MIAC links the most recent input-output (IO) tables with past table (for example, the 2005 IO tables with the 2000 and 1995 tables) and converts nominal values of past years (e.g., 1995 and 2000) to values in prices of the most recent year (2005 in our example). For this purpose, MIAC creates deflators (past nominal values of 5 and 10 years ago are inflated by the inflation rate of later years; the adjustment terms are called “inflators”) for each sector at the basic classification level. MIAC provides relatively detailed information on how each “inflator” is created. From this information, we can guess how deflators in Japan’s GDP statistics are created. However, it is said that the *Linked Input-Output Tables* tend to depend more on unit prices derived from data from the *Census of Manufactures* and *Customs Statistics*, whereas the GDP statistics tend to depend more on the *Producer Price Index* and the *Consumer Price Index*.

Source: World KLEMS Data, April 2013 release, EU KLEMS Data (in the ISIC Rev. 4 industry classification), and JIP Database 2015.

In addition to comparing estimation methods, another aim of this paper is to compare changes in total factor productivity (TFP) and gross output prices in the five sectors in Japan with those in the United States and the UK using standard KLEMS-type databases. Specifically, we use the World KLEMS Data (April 2013 release) for the United States, the EU KLEMS Data (in the ISIC Rev. 4 industry classification) for the UK, and the JIP Database 2015 for Japan.^{3, 4} Since these three datasets use the GDP of each country as the control total, we think that this comparison allows us to make conjectures about the extent to which measurement issues account for differences in estimated sectoral TFP growth across the three countries.^{5, 6}

The structure of the paper is as follows. Sections 2 to 5 each examine one or two of the five sectors we focus on, discussing measurement issues and comparing changes in Japan's sector TFP and gross output deflator with those in the United States and the UK. Moreover, based on the comparisons, we make conjectures about the extent to which measurement issues affect estimated TFP growth. Specifically, Section 2 focuses on construction, Section 3 on wholesale and retail, Section 4 on education and health care, and Section 5 on public administration and defense, and compulsory social security. Finally, Section 6 summarizes our findings.

2. Construction

In Japan's GDP statistics, nominal output of construction is calculated by summing up all intermediate input costs (which are estimated from commodity flow data) plus gross value added (labor costs plus operating surplus).⁷ Real output is obtained by using an input price index as the deflator. Under this convention, which essentially equates output with inputs, if the input price index covers all inputs, measured TFP growth will be close to zero, which in fact is the case in the statistics on many general government activities (see Section 5). However, in the case of Japan's GDP statistics on construction, since the "output=inputs" convention is not fully applied in at least three aspects, measured TFP changes over time. That is, given that the efficiency with which inputs in any given

³ Gross output deflators for the UK are from the EU KLEMS Data (November 2009 Release, updated March 2011).

⁴ For details about the World KLEMS Data, the EU KLEMS Data, and the JIP Database 2015, see Jorgenson, Ho, and Samuels (2012), O'Mahony and Timmer (2009) and Fukao et al. (2007), respectively.

⁵ Another important difference in service sector statistics between Japan and the United States is that, in the United States, based on the North American Industry Classification System, management of companies and enterprises is included in private services-producing industries. However, in Japan, such activities are included in the industry to which a firm belongs. For example, activities related to the management of companies and enterprises belonging to manufacturing firms are included in the manufacturing sector.

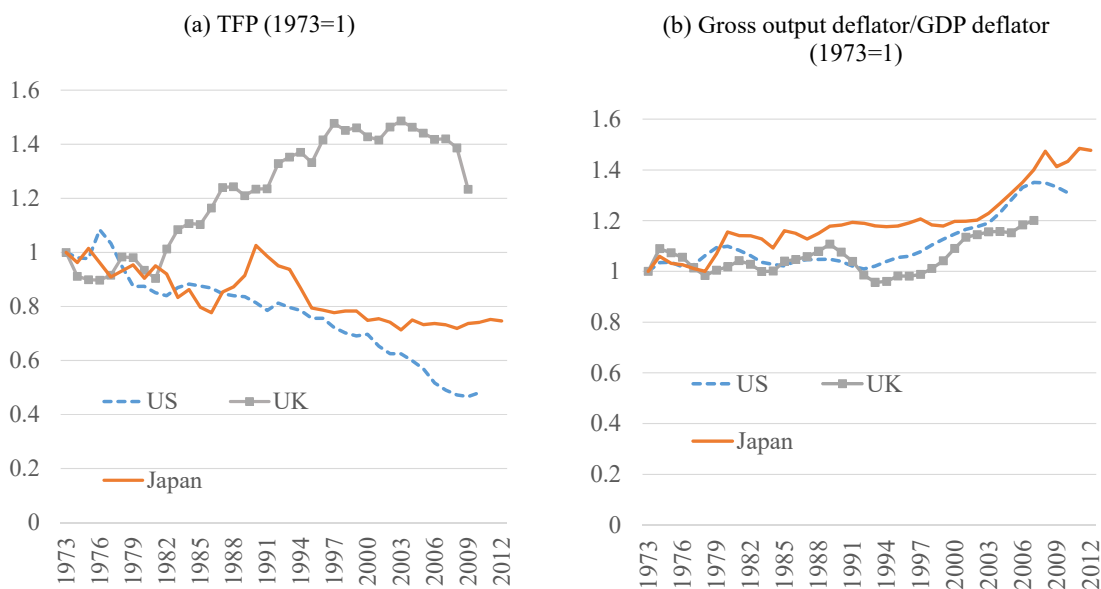
⁶ For our international comparison, we use the industry classification of the World KLEMS Data.

⁷ For more detailed information, see ESRI (2012) and Takayama et al. (2013).

sector are used can be expected to change over time, TFP of that sector should change accordingly. However, due to the “output=inputs” convention, such changes are not captured and *measured* TFP should remain unchanged. Yet, in practice, the “output=inputs” convention is applied only incompletely, so that measured TFP *does* change, but for reasons that are not necessarily related to any changes in “true” TFP.

First, the output measure does not entirely consist of information on factor inputs but also includes the operating surplus in nominal output. Therefore, when the construction sector enjoys a high profit rate, its measured TFP growth accelerates. Figure 1 shows changes in TFP (measured on a value added basis; 1973=1) and the gross output deflator/GDP deflator ratio for the construction sector in Japan, the United States, and the UK. Consistent with our conjecture, Figure 1(a) shows that in Japan, measured TFP increased substantially during the period of the bubble economy from 1986 to 1991. (Developments in the United States and the UK are considered at the end of this section.)

Figure 1. Developments in TFP and the Gross Output Deflator in the Construction Sector: Japan-US-UK Comparison



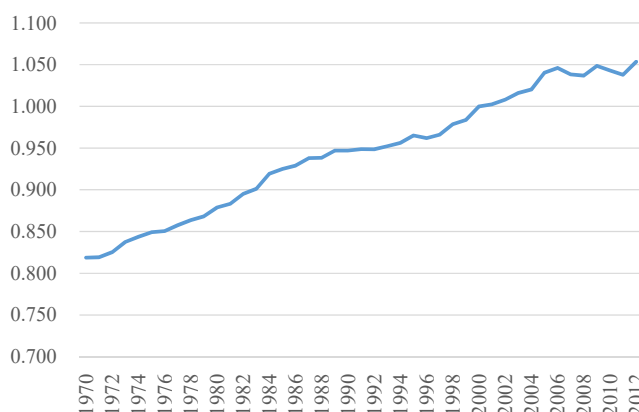
Source: World KLEMS Data, EU KLEMS Data, and JIP Database 2015.

Second, Japan’s deflator for the construction sector takes account only of intermediate input prices and wage rates (Takayama et al. 2013) and takes neither capital service prices ((interest rate + capital depreciation rate – capital gains) × capital stock price) nor the cost of capital depreciation into account. Since capital service prices and the cost of capital depreciation tend to increase slower than intermediate input prices as well as wage rates, Japan’s deflator for the construction sector

overestimates the increase in overall input prices. It is probably for this reason that the gross output deflator/GDP deflator ratio for Japan’s construction sector has increased substantially (Figure 1(b)). This results in an underestimation of TFP growth in the construction sector.

Third, Japan’s deflator for the construction sector does not take account of changes in labor quality (Takayama et al. 2013). Since labor quality in the construction sector has increased over time, wage rate increases are overestimated and growth of real output and TFP are underestimated. According to the JIP Database 2015, during the period 1970–2012 labor quality increased at an annual rate of 0.60% (Figure 2).⁸ Since labor costs / (labor costs + capital service costs) in the construction sector are quite high (around 0.90), both real value added growth and TFP growth (on a value added basis) for the period 1973–2012 are underestimated by 21 percentage points ($0.60 \times 0.90 \times 39 = 21$).⁹ Given that the average share of the gross value added in this sector in GDP during this period was 8.0%, this means that Japan’s GDP statistics underestimates real GDP growth by 1.7 percentage points for the period 1973–2012, and the JIP Database underestimates TFP growth in the economy as a whole by 1.7 percentage points for the same period.

Figure 2. Quality of Labor in the Construction Sector



Source: JIP Database 2015.

To sum up, these considerations suggest that both the decline in the TFP level of Japan’s construction sector over the period as a whole as well as the hump during and after the period of the bubble economy are statistical artifacts caused by deficiencies in Japan’s GDP statistics. Moreover, Japan’s GDP statistics also substantially underestimates real GDP growth.

⁸ In contrast with Japan, the quality of labor input in the UK construction sector declined during the period 1997–2005 (ONS 2007). Therefore, estimated TFP growth becomes lower when the ONS takes quality change in labor input into account.

⁹ The figure is obtained by comparing a hypothetical official input index which takes capital service input but not labor quality into account and a KLEMS-type input index which takes both capital service input and labor quality into account.

If reliable data on construction output prices were available, this would allow us to derive more reliable real output and TFP measures. Unfortunately, however, there are no government statistics in Japan providing construction output prices.¹⁰

The situation in the United States and the UK stands in stark contrast to that in Japan. In the United States, the Bureau of Economic Analysis (BEA) creates (quality adjusted) price deflators for construction output based on broad types of structure, using price indexes such as the Producer Price Index (PPI) for new health care building construction (published by the Bureau of Labor Statistics).¹¹ Similarly, in the UK, the Office for National Statistics (ONS) estimates real output of the construction sector using price deflators for construction output such as the construction price and cost indices (CPCIs) of the Department for Business, Innovation and Skills (BIS).¹²

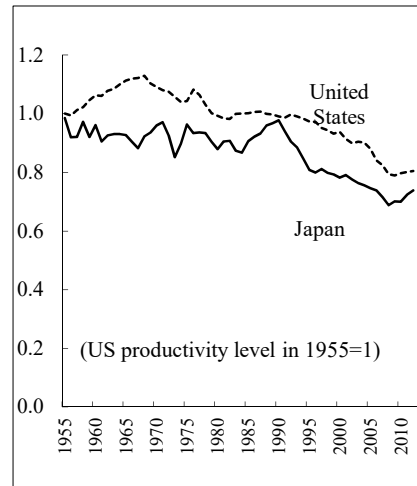
That being said, as can be seen in Figure 1(a), according to the World KLEMS Data, the derived TFP index for the United States steadily declined throughout the period covered by the data. Similarly, Figure 3, which is based on TFP estimates (on a gross output basis) obtained by Jorgenson, Nomura, and Samuels (forthcoming), also suggests that TFP in the US construction sector steadily declined from around 1970 onward. Since it is difficult to believe that the technology level of the US construction sector or the efficiency of resource allocation within that sector continued to deteriorate for 40 years, it seems that the US statistics also suffer from some serious problems. On the other hand, in the case of the UK, estimated TFP grows in a plausible manner, as shown in Figure 1.

¹⁰ The only data on construction output prices available in Japan are provided by Construction Research Institute, a non-profit foundation, which collects cost data on certain construction activities (excluding material costs) such as certain types of reinforcement work and publishes such data in two quarterly reports, *Kikan Kensetsu Kosuto Joho (Unit Price of Construction Works, Quarterly)* and *Kikan Doboku Kosuto Joho (Unit Price of Civil Engineering Works, Quarterly)*.¹¹

¹¹ For more details, see BEA (2015) and Barefoot, Morgan, and Shadrina (2015). The US Census Bureau also creates price indexes for new houses under construction. Moreover, many European countries also create (quality adjusted) price deflators for construction output (see OECD/Eurostat 1997).

¹² On April 1st, 2015, responsibility for the production of the CPCIs was transferred from the BIS to the ONS (ONS 2015a).

**Figure 3. Absolute TFP Level of the Construction Sector (on a Gross Output Basis)
Based on PPP Data: US-Japan Comparison**



Source: Jorgenson, Nomura, and Samuels (forthcoming).

3. Wholesale and Retail

Next, we examine GDP statistics on wholesale and retail. As OECD/Eurostat (2014) points out, if the quality of wholesale or retail services per unit of traded commodities does not change over time, the margin price per unit, i.e.,

$$\text{Margin price per unit} = \text{Selling price per unit} - \text{Purchase price per unit} \quad (1)$$

will be the appropriate measure of the price of services provided by wholesalers and retailers. The BEA recently started to use margin price data collected by the Bureau of Labor Statistics (BLS) as part of the Producer Price Index (PPI) for their estimation of deflators for wholesale and retail activities (Mayerhauser and Strassner 2010, Gilmore, et al. 2011).¹³ Canada also started to use margin price data for their estimation of deflators for wholesale and retail activities (OECD/Eurostat 2014). In order to correctly measure changes in the margin price per unit by adjusting for changes in the quality of trade services, statistical offices collect margin price data for transactions in specified groups of commodities with specified groups of suppliers/customers for each of the traders surveyed. Therefore, when the trade share of a certain type of transactions with a high margin price increases, this is not regarded as an increase in the price of trade services but as an increase in service output. However, if service quality, such as the hours of operation or the variety of commodities offered for sale, improves in each transaction in a specified group of commodities with a specified group of suppliers/customers for each of the traders surveyed, such quality improvement is not recorded as output growth. One way

¹³ For details on the margin price data of the BLS, see Swick, Bathgate, and Horrigan (2006).

to resolve this problem and measure such quality change is to collect information on numerous service characteristics, such as the hours of operation, the variety of commodities offered for sale, etc., and estimate a hedonic model. However, few countries employ this approach, with the United States not being an exception (OECD/Eurostat 2014).

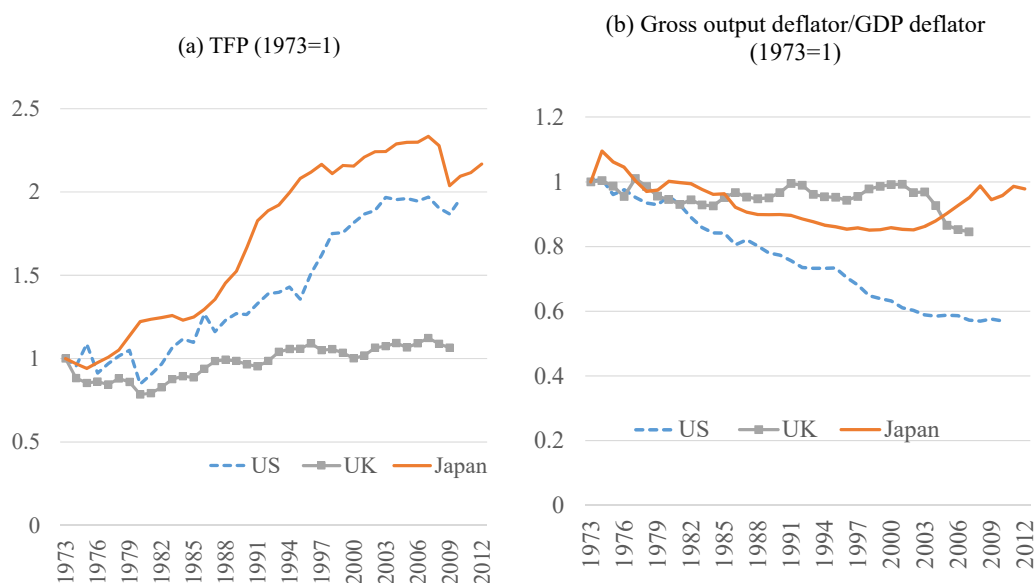
While the United States and Canada have started to use margin prices, most other countries, including Japan and the UK,¹⁴ still use the prices of traded commodities as deflators for the wholesale and retail sector. Since the margin price per unit (selling price per unit – purchase price per unit) is equal to the margin rate ((selling price per unit – purchase price per unit) / purchase price per unit) multiplied by the purchase price per unit, this approach implicitly assumes that the margin rate is constant over time.

Figure 4 presents developments in Japan's TFP and gross output deflator for the wholesale and retail sector with those in the United States and the UK. In the case of Japan, probably reflecting the worldwide boom in natural resource prices in the 2000s, the gross output deflator-GDP deflator ratio increased substantially until the global financial crisis, which contrasts with developments in the United States, where this ratio continued to decline in the 2000s. Moreover, probably partly reflecting this increase in the gross output deflator-GDP deflator ratio, Japan's TFP growth in the sector slowed in the 2000s. These results are confirmed by Figure 5, which presents Jorgenson, Nomura and Samuels' estimation of TFP levels. The figure again indicates that Japan's TFP level stagnated in the 2000s. Turning to the UK, Figure 4 shows that the gross output deflator-GDP deflator ratio declined substantially, which probably reflects the appreciation of the pound in 2006–2007. However, the increase in the gross output deflator-GDP deflator ratio did not cause a substantial slowdown in estimated TFP growth during this period.

When we compare the long-run trend of the gross output deflator-GDP deflator ratio in the three countries, what clearly stands out is the decline in the ratio in the United States. Moreover, the decline in this ratio and the increase in TFP accelerated in the second half of the 1990s and the first half of the 2000s. This phenomenon has been regarded as important evidence of the information and communication technology (ICT) revolution in the United States (Inklaar, Timmer, and van Ark 2006). In this context, it should be noted that the BEA introduced the use of margin price data around 2010 and made retrospective corrections for past data (Mayerhauser and Strassner 2010, Gilmore, et al. 2011). However, the acceleration in TFP growth in the US wholesale and retail sector was already observed in 2006 (Inklaar, Timmer, and van Ark 2006), so it seems unlikely that this acceleration is simply a statistical artifact caused by changes in the way deflators are calculated. Nevertheless, it is important to bear this issue in mind in future international comparisons for this sector.

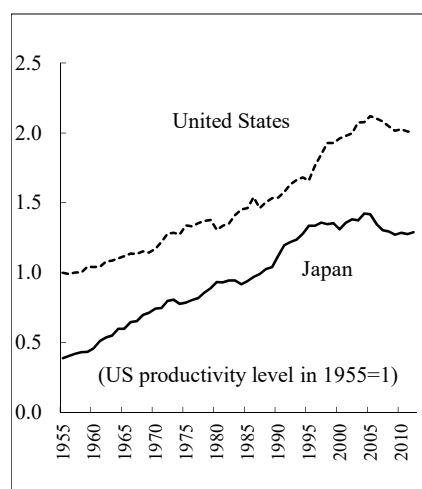
¹⁴ For information on deflators used in the UK, see ONS (2014, 2016).

Figure 4. Developments in TFP and the Gross Output Deflator in the Wholesale and Retail Sector: Japan-US-UK Comparison



Sources: World KLEMS Data, EU KLEMS Data, and JIP Database 2015.

Figure 5. Absolute TFP Level of the Wholesale and Retail Sector (on a Gross Output Basis) Based on PPP Data: US-Japan Comparison



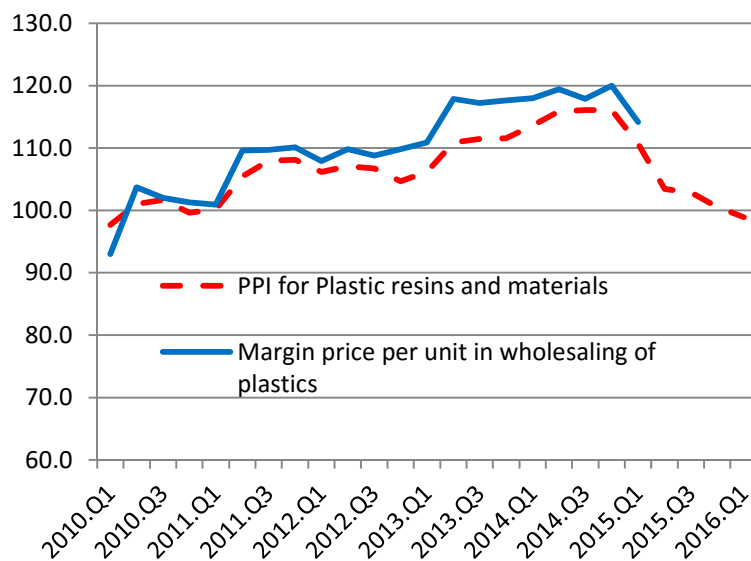
Source: Jorgenson, Nomura, and Samuels (forthcoming).

Looking at Japan, it is difficult to assess how much of the increase in the gross output deflator-GDP deflator ratio in the 2000s (Figure 4) is caused by the fact that Japan uses the prices of traded commodities as deflators for the wholesale and retail sector. However, the Bank of Japan (BOJ) recently started a wholesale service price survey and estimated the margin price per unit in domestic

wholesale trade for three commodity categories – food and beverages, plastics, and electronic parts and devices – on a trial basis as a part of its work on the Services Producer Price Index (Research and Statistics Department, Bank of Japan 2014).¹⁵ In the case of plastics, we can compare the BOJ’s margin price per unit in wholesaling with the BOJ’s PPI for plastic resins and materials that are included in chemical products.

This is done in Figure 6, which shows the PPI for plastic resins and materials and the margin price per unit in the wholesaling of plastics. Unfortunately, the data are available only from 2010. Therefore, we cannot compare the two series for the period before the global financial crisis. For the period after 2010, the figure indicates that the margin price per unit in the wholesaling of plastics increased more than the PPI for plastics. This means that, for this period, if we measure the TFP of wholesaling of plastics using the margin price per unit as deflator, the measured TFP growth rate will become lower than measured TFP growth based on the PPI.¹⁶

Figure 6. Comparison of the PPI for Plastic Resins and Materials and the Margin Price per Unit in Wholesaling of Plastics: 2010=100 (Consumption Tax is Excluded)



Sources: Research and Statistics Department, Bank of Japan (2014) and Bank of Japan, *Producer Price Index*.

4. Education and Health Care

¹⁵ When the BOJ reports the margin price per unit, it makes adjustments for quality changes in traded commodities. For example, when the margin price of a laptop computer stays constant but the quality of the computer improves by 10%, the BOJ’s margin price declines by 10%. However, in the case of the United States, the BLS does not make such adjustment for quality changes when it reports the margin price per unit.

¹⁶ In the case of food and beverages, the BOJ’s margin price per unit declined substantially from 2010.

Measurement of output and deflators in non-market service sectors such as education and health care is problematic because in these sectors prices are not determined in competitive markets. In education and health care, governments often intervene into the market mechanism through regulations, social insurance systems, and other measures. Even without government interventions, prices determined in the market probably do not reflect true consumer preferences because of asymmetric information and externalities.

Given these problems, recent years have seen growing interest in the use of direct measures of the output of non-market service sectors such as education and health care. For instance, the Atkinson Review (2005) recommends to measure output directly by counting the number of units for whom services are provided instead of measuring output by aggregating inputs for the production of the service. In addition, the review recommends adjusting output for changes in the quality of services. Similarly, Eurostat (2001) recommends the use of direct measures with quality adjustments. In the UK, the ONS estimates and publishes direct and quality-adjusted output indexes for public sector activities. In the United States, important research has been conducted, particularly at the National Bureau of Economic Research (NBER), to measure the quality of health care and adjust estimated deflators by changes in quality (Cutler and Berndt 2001). The BEA is now developing a Health Care Satellite Account, which is based on detailed information about health care treatments (Dunn, Rittmueller, and Whitmire 2015). Interestingly, although many important studies on how to measure the quality of public services are authored by scholars and statisticians in the United States, it seems to be the government of the UK that is the most proactive and advanced in implementing the results of such studies.

Therefore, in this section, we first take a look at the new output indexes of the ONS in the UK. We also try to obtain rough estimates of the output and TFP of Japan's education and health care service sectors using the direct method and adjusting for quality changes.

An explanation of the methodology and the results of the new measurement of output and productivity is provided in various ONS publications (ONS 2013, 2015b, 2015c, 2015d). Activities covered in these estimates include health care, education, social security administration, adult social care, children's social care, public order and safety, and some other areas.

The method of measuring output is chosen based on the availability of data for each type of activity.¹⁷ In the case of health care and education, the direct measure of output with quality adjustment is used.¹⁸ In the case of social security administration, adult social care, and children's social care, the direct measure of output without quality adjustment is used.¹⁹ Public order and safety

¹⁷ In the case of public services, for instance, 64% of the total value of output is estimated through direct measures, while 36% is estimated following the "output=inputs" convention.

¹⁸ Approximately 9% of the total value of health care output is delivered by non-National Health Service providers and is measured using the "output=inputs" convention.

¹⁹ Around 60% of the total value of children's social care output is for "non-looked-after" children and is

and other areas are measured based on the traditional input approach using the “output=inputs” convention.

The data used for the direct measure of output for each type of activity are as follows. For health care, hospital inpatients, general practitioner (GP) consultations, and drugs prescribed by GPs are used. For education, the number of pupils or students in preschools and in primary, secondary, and higher education adjusted for absence are used. For social security administration, recipients of pension and unemployment benefits are used. For adult social care, weeks of residential care, meals provided, etc., are used. For children’s social care, days spent in short term placement, the number of children in secure accommodation or children’s nursing homes, etc., are used. For public order and safety, the number of fires responded to by fire brigades, court cases, prisoners in prisons, etc., are used.

The direct measure of output without quality adjustment is calculated by aggregating the growth rate of the output of each type of activity using cost share weights:

$$Q_t = Q_{t-1} \left(\sum_j \left(\frac{a_{j,t} - a_{j,t-1}}{a_{j,t-1}} \frac{a_{j,t-1} x_{j,t-1}}{\sum_j a_{j,t-1} x_{j,t-1}} \right) + 1 \right)$$

Q : Quantity index at time t .

$a_{j,t}$: Quantity of service j at time t .

$x_{j,t}$: Unit cost of service j at time t .

$\frac{a_{j,t-1} x_{j,t-1}}{\sum_j a_{j,t-1} x_{j,t-1}}$: Cost share of service j at time t .

The above equation can be transformed into

$$Q_t = Q_{t-1} \left(\frac{\sum_j a_{j,t} x_{j,t-1}}{\sum_j a_{j,t-1} x_{j,t-1}} - 1 \right) + 1. \quad (2)$$

In the case of health care, factor that are taken into account to adjust for quality are patients’ health gains, short-term survival rates, waiting times, patient satisfaction, etc. In the case of education, test scores are used for quality adjustment.

The direct measure of output with quality adjustment, O_t , is obtained by multiplying the quantity index of each service j by the quality measure, q_{jt} :

measured using the “output=inputs” convention.

$$O_t = O_{t-1} \left(\sum_j \left(\frac{q_{j,t} a_{j,t} - q_{j,t-1} a_{j,t-1}}{q_{j,t-1} a_{j,t-1}} \frac{a_{j,t-1} x_{j,t-1}}{\sum_j a_{j,t-1} x_{j,t-1}} \right) + 1 \right)$$

The above equation can be transformed into

$$O_t = O_{t-1} \left\{ \left(\frac{\sum_j a_{j,t} x_{j,t-1}}{\sum_j a_{j,t-1} x_{j,t-1}} - 1 \right) + \left(\frac{\sum_j \frac{q_{j,t}}{q_{j,t-1}} a_{j,t-1} x_{j,t-1}}{\sum_j a_{j,t-1} x_{j,t-1}} - 1 \right) \right\} + 1. \quad (3)$$

Figure 7 compares the annual average growth rate of TFP across public services categories from 1997 to 2010. In the case of health care and education, where the direct measure of output with quality adjustment is used, positive TFP growth is observed. In the case of categories where the direct measure of output without quality adjustment is used the results are mixed. TFP growth was positive in social security administration. However, it was negative in the case of adult social care, children's social care, and public order and safety. The TFP growth in areas such as policing and defense as well as other areas is, by definition, zero because output in these areas is measured by inputs.

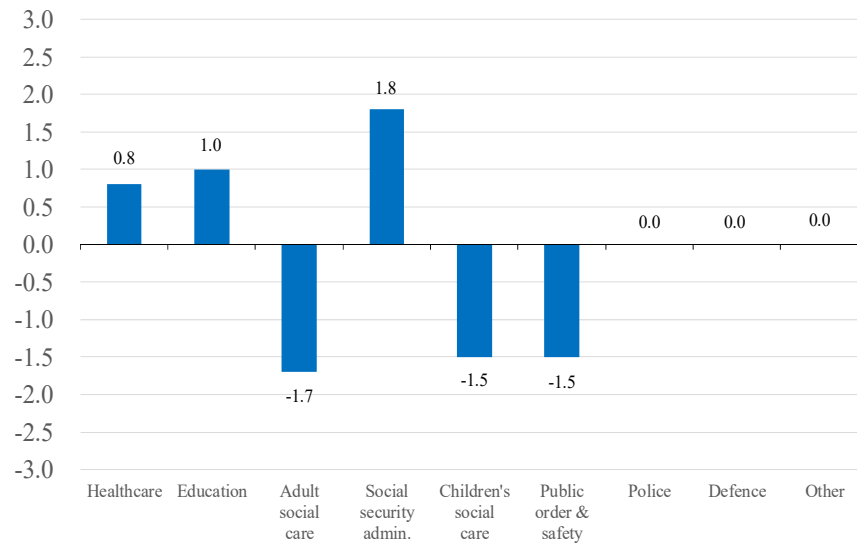
Next, Figure 8 shows the effect of quality adjustment in health care. The direct measure of output with quality adjustment shows a more rapid increase than the direct measure of output without quality adjustment. This means that the quality of health care services steadily improved.

Figure 9 shows changes in TFP, the direct measure of output with quality adjustment, and the input index for the health care sector. Until the early 2000s, productivity barely increased due to strong increases in inputs. In the mid-2000s, with the continued growth of output and a deceleration of input growth, the TFP of health care increased. If the direct measure of output without quality adjustment is used to calculate TFP, virtually no TFP growth can be observed from 1995 to 2010.

Focusing on the period from 1996 to 2013, Figure 10 turns to developments in the direct measure of output with and without quality adjustment for education. The direct measure of output without quality adjustment stagnated throughout the period, while the measure with quality adjustment grew rapidly.

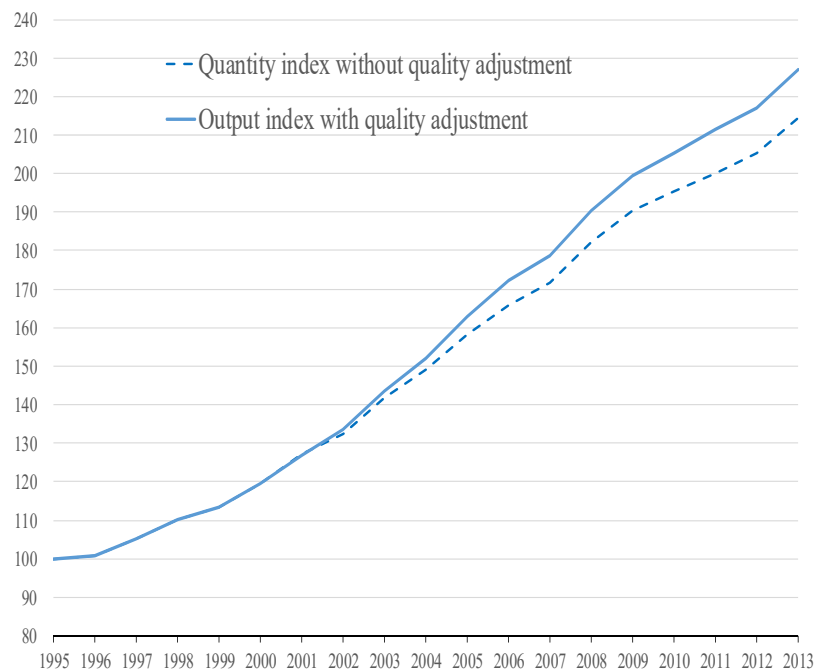
Figure 11 shows developments in TFP, the direct measure of output with quality adjustment, and the input index. After rapid growth from 1996–99, TFP declined by about 10% between 1999 and 2009. However, TFP started to increase again after 2009. This revival of TFP growth in education reflects a rise in output quality and a sharp slowdown of input growth. If the direct measure of output without quality adjustment is used in place of the measure with quality adjustment, no growth in TFP is observed from 2009.

Figure 7. Annual Average Growth Rate of TFP in UK Public Services, 1997–2012 (in %)



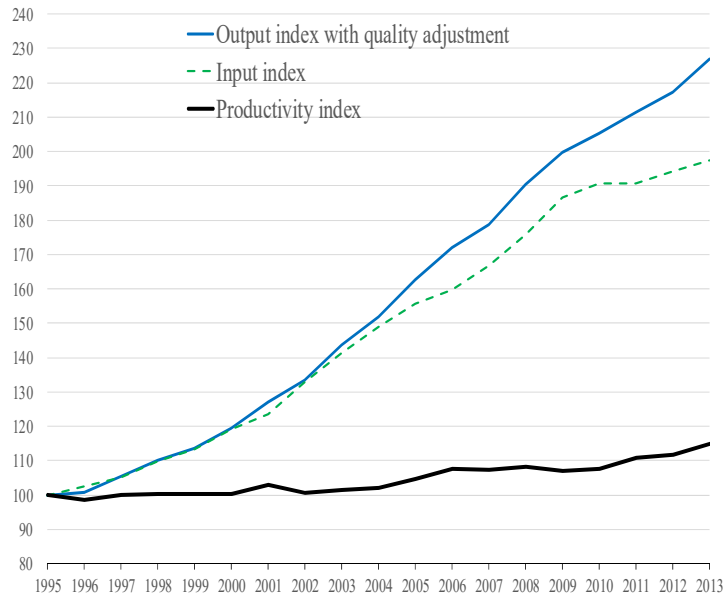
Source: ONS (2015b).

Figure 8. Developments in the Direct Measure of Output with Quality Adjustment and the Direct Measure of Output without Quality Adjustment: Healthcare, 1995–2013



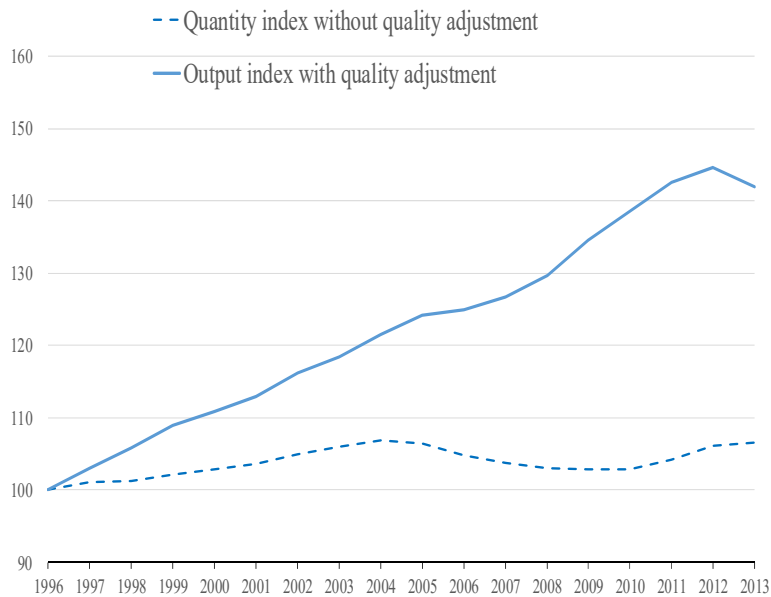
Source: ONS (2015c).

Figure 9. Developments in the Direct Measure of Output with Quality Adjustment, the Input Index, and TFP: Healthcare, 1995–2013



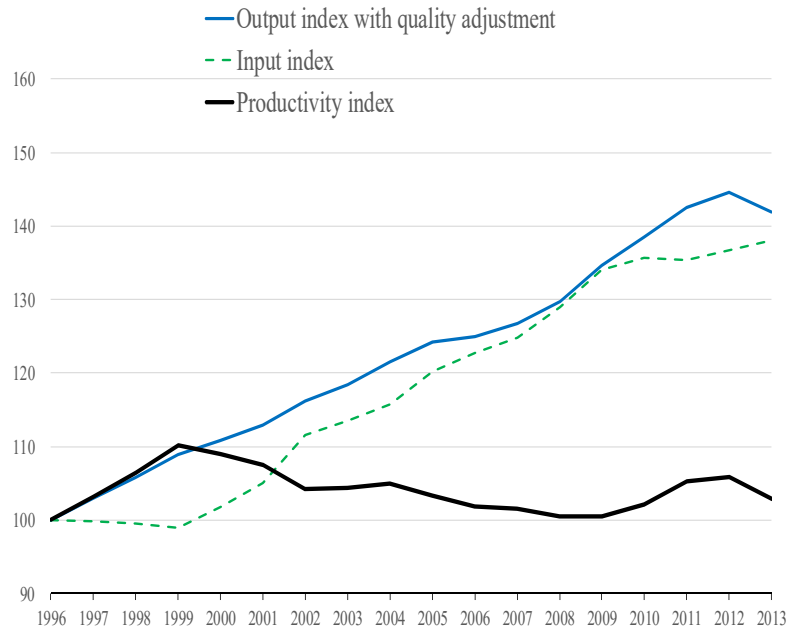
Source: ONS (2015c).

Figure 10. Developments in the Direct Measure of Output with Quality Adjustment and the Direct Measure of Output without Quality Adjustment: Education, 1996–2013



Sources: ONS (2015d).

Figure 11. Developments in the Direct Measure of Output with Quality Adjustment, the Input Index, and TFP: Education, 1996–2013



Sources: ONS (2015d).

Turning to Japan and the United States, nominal output of most activities in the education sector is measured using total input costs. Moreover, real output is calculated by deflating nominal output using an input price index that covers intermediate, labor, and capital service inputs (BEA 2015, ESRI 2012). Meanwhile, wages are adjusted using changes in labor quality.²⁰ Under this output=inputs approach, measured TFP growth will be almost zero.

Figure 12 provides a comparison of developments in TFP and the gross output deflator in the education sector. The TFP results for the UK are not shown in the figure, because the results by the ONS shown in Figure 11 are more up to date. Contrary to our expectation that TFP growth in the education sector in Japan and the United States would be almost constant, Figure 11 shows there are some substantial changes in TFP over time. In the case of the United States, TFP declined by 20% from 1973 to 2010. On the other hand, in the case of Japan, TFP follows a hump-shaped pattern. How can these developments in TFP be explained?

Several factors underlying the developments in the TFP measures can be pointed out. In order to explain this issue clearly, let us mathematically explain the relationship between nominal output, the

²⁰ When the share of highly educated workers in total workers increases, total production costs will increase. However, the quality adjusted input price index will not increase. An increase in the share of highly educated workers therefore will be regarded as an improvement in the quality of inputs (and output).

input price index, and (gross output based) TFP under the “output=inputs” convention.

We define the nominal total output of education, Y , in terms of the total costs of this sector, $wL+rK+qM$, where w denotes the wage rate, L labor input, r the price of capital services, K the capital stock, q intermediate input prices, and M intermediate inputs. In the standard KLEMS-type approach, We assume all the variables are smooth functions of time. Differentiating the total costs with respect to time, we have the following equation:

$$\hat{Y} = (s_L \hat{w} + s_K \hat{r} + s_M \hat{q}) + (s_L \hat{L} + s_K \hat{K} + s_M \hat{M}) \quad (4)$$

where s_L , s_K , and s_M denote the cost share of labor, $(wL/(wL+rK+qM))$, the cost share of capital, $(rK/(wL+rK+qM))$, and the cost share of intermediate inputs, $(qM/(wL+rK+qM))$, respectively. The sum of the three shares is equal to one. The circumflex accent, $\hat{\cdot}$ above variables denotes growth rate of those variables. In the standard KLEMS-type approach, when we calculate these growth rate terms, such as growth rate of w and L , we take account of quality changes caused by changes in composition of inputs, such as an increase of highly educated workers. The first term on the right-hand side denotes the total input price index and the second term denotes the total factor input index.

From equation (4), we obtain

$$\hat{Y} - (s_L \hat{w} + s_K \hat{r} + s_M \hat{q}) = (s_L \hat{L} + s_K \hat{K} + s_M \hat{M}) \quad (4')$$

Employing the output=inputs approach, we use the total input price index as the deflator for total output. Moreover, we calculate the growth rate of real total output as the growth rate of nominal total output minus the growth rate of the total input price index (the left-hand side of equation (4')). Therefore, the growth rate of real total output is equal to the growth rate of the (quality adjusted) total factor input index (the right-hand side of equation (4)). Since real total output growth is equal to total factor input growth, measured (gross output based) TFP growth becomes zero.

We can also show that measured (value added based) TFP growth will also become zero under the “output=inputs” convention in the following way. The growth rate of real value added, V , is expressed by

$$\hat{V} = \frac{s_L + s_K + s_M}{s_L + s_K} \left(\hat{Y} - (s_L \hat{w} + s_K \hat{r} + s_M \hat{q}) \right) - \frac{s_M}{s_L + s_K} \hat{M}$$

Therefore, we have

$$\hat{V} - \frac{s_L}{s_L + s_K} \hat{L} - \frac{s_K}{s_L + s_K} \hat{K} = \frac{s_L + s_K + s_M}{s_L + s_K} \left(\hat{Y} - (s_L \hat{w} + s_K \hat{r} + s_M \hat{q}) - (s_L \hat{L} + s_K \hat{K} + s_M \hat{M}) \right)$$

where the left-hand side denotes value added based TFP. Meanwhile, equation (4) implies that the right-hand is equal to zero.

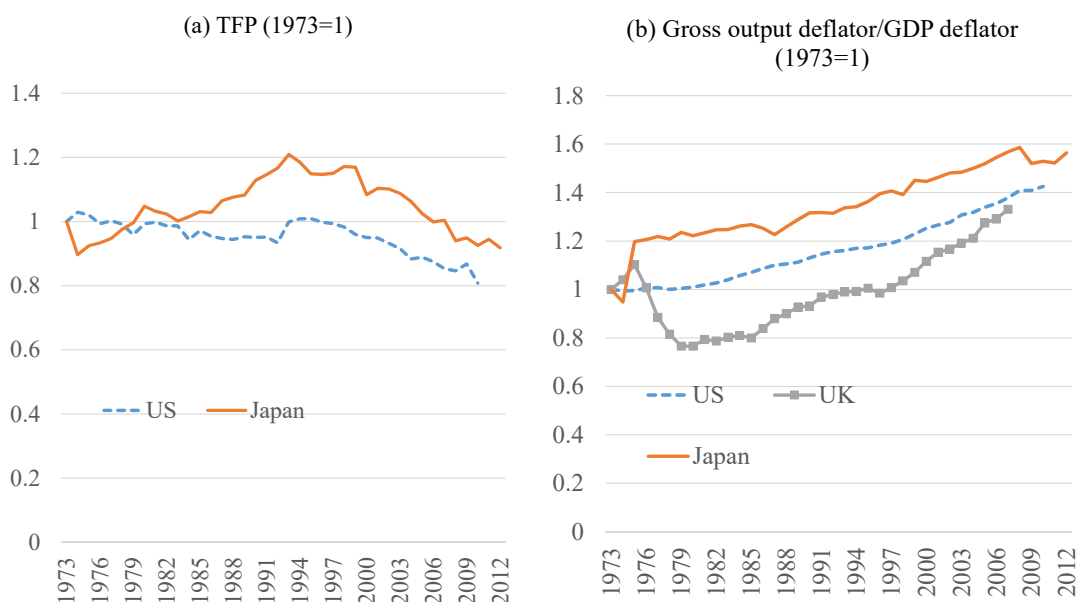
Measured TFP in Figure 12(a) changes over time, because real output growth of GDP statistics and total factor input growth of KLEMS-type data are based on different measure of variables, such as L and r .

First, when we calculate KLEMS-type measure of total factor input, we use ((interest rate + capital depreciation rate – capital gains) × capital stock price) as capital service price, r . However, both in Japan and the United States, only capital depreciation, (capital depreciation rate × capital stock price) is counted as capital service price, r , in the education sector. Since interest rate tend to be greater than capital gains in Japan, the cost share of capita used in the calculation of the total factor input growth is greater than the cost share of capital used in the calculation of the real total output growth. For this reason, there is a gap between the growth rate of the real input index in the GDP statistics and the growth rate of the real input index estimated using the KLEMS approach for growth accounting. And this gap makes TFP not equal to zero.

Second, in the case of Japan, the GDP statistics do not make adjustments for labor quality in the case of private schools (most of which are non-profit organizations) in the estimation process of input prices (Takayama et al. 2013). This results in an underestimation of improvements in the quality of output and of TFP growth.

And third, data on intermediate input prices and changes in labor quality used for TFP analysis might be different from the data used for the GDP statistics. For these reason, TFP growth is not always equal to zero.

**Figure 12. Developments in TFP and the Gross Output Deflator in the Education Sector:
Japan-US-UK Comparison**



Sources: World KLEMS Data, EU KLEMS Data, and JIP Database 2015.

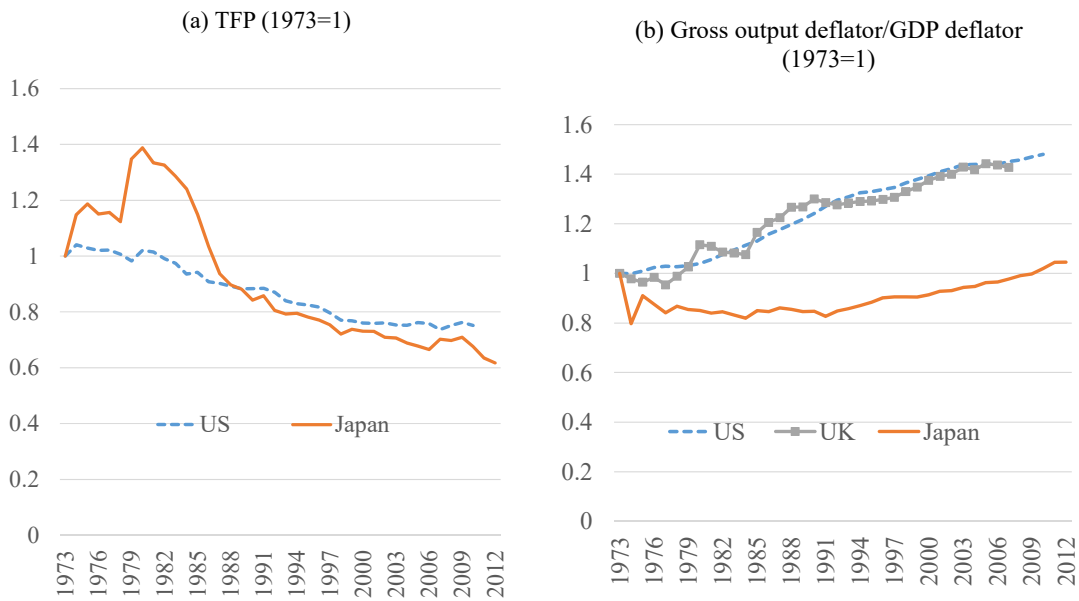
In the case of health care, both in Japan and the United States GDP deflators are estimated based on observable output prices. In Japan, GDP deflators of most activities in health care sector are obtained by using *Consumer Price Index (CPI)*. The exception is nursing facility service²¹ in which real output is calculated by deflating nominal output using an input price index that covers intermediate and labor service inputs. Data on wages are from *Monthly Labor Survey* published by Ministry of Health, Labor and Welfare which does not take account of changes in labor quality. The other activities in health care sector use output prices, for example, consultation fees or hospital charges for delivery in *CPI*. However, they don't necessarily reflect quality change in output. Similarly, in the United States, *CPI* and *Producer Price Index (PPI)* are used for deflators, such as *PPI* for offices of physicians or *CPI* for dental services.

Figure 13 compares developments in TFP and the gross output deflator in the health care sector in the three countries. Again, the TFP of the UK is not shown because more up-to-date results by the ONS were already presented in Figure 9. Figure 13 indicates that both in the United States and Japan, TFP declined substantially over time. Meanwhile, Figure 14 shows the absolute TFP level of health care services in Japan and the United States (Jorgenson, Nomura, and Samuels, forthcoming). The figure again indicates that TFP declined substantially in the United States, although it did not change

²¹ Nursing facility service and home service are almost the same amount in nominal output in *Linked Input-Output Tables* (see footnote 2).

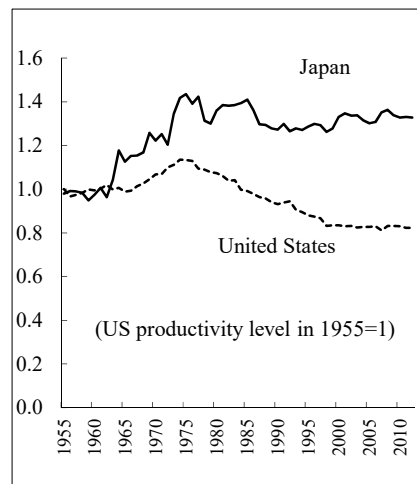
much in Japan. These results suggest that we know very little about TFP in this sector and that more research is required.

Figure 13. Developments in TFP and the Gross Output Deflator in the Health Care and Social Work Sector: Japan-US-UK Comparison



Source: World KLEMS Data, EU KLEMS Data, and JIP Database 2015.

**Figure 14. Absolute TFP Level of Medical Care Services (on a Gross Output Basis)
Based on PPP Data: US-Japan Comparison**



Source: Jorgenson, Nomura, and Samuels (forthcoming).

Next, following the ONS, we try a very preliminary experiment to estimate a direct measure of output with quality adjustment for education and health care.

In the case of education, we use the number of students as the direct measure of output and employ test scores to measure the quality of education. The direct measure of output (number of students) is calculated for four school categories, namely, primary schools, junior high schools, senior high schools, and universities, which includes both undergraduate and graduate school. Each school category consists of private, public, and national schools. We then aggregate these four direct measures of output using the expenditure on each of the four school categories as weights.

Data on the number of students are taken from the *Basic Survey of Schools* conducted by the Ministry of Education, Culture, Sports, Science and Technology. Figure 15 shows the number of students by school category. The total number of students has been declining steadily. The number of students at primary, junior, and senior high schools are declining, while the number of university students is increasing.

As test score data, we use the *National Survey of Academic Attainment* for primary and junior high school students and the results of the National Center Test for University Admissions for senior high school students. Figure 16 shows the average scores. We assume that the difficulty of tests did not change over time and that we can use test scores for intertemporal comparisons of educational attainment. Test scores at the senior high school level have been declining, while they have moved up and down at the primary and junior high school levels

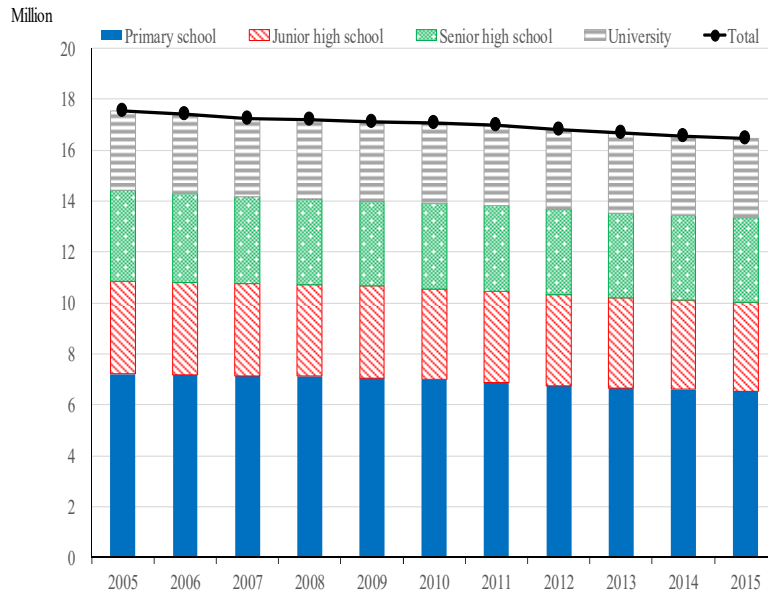
Developments in the calculated direct measure of output with and without quality adjustment and the quality index are shown in Figure 17. We calculated the first two measures using equations (2) and (3). The third measure – the quality index – is derived by dividing the direct measure of output with quality adjustment by the direct measure of output without quality adjustment. Since the quality index is on a declining trend, the direct measure of output with quality adjustment declined more than that without quality adjustment from 2005.

Next, to calculate (gross output based) TFP in the education sector, we divide our direct measure of output with quality adjustment by an index of total inputs. The total input index is derived from the JIP Database 2015. The total input data cover intermediate inputs, capital service input, and labor input. Moreover, the labor input data are quality adjusted for all workers in the education sector. According to our new estimate, TFP in Japan's education sector declined by about 9% from 2005 to 2012 (Figure 18).

We can also obtain a new (implicit) deflator with quality adjustment for the education sector by dividing total gross output of the education sector by our new direct measure of output with quality adjustment. Figure 19 compares our new deflator with the gross output deflator in the JIP Database 2015. The original source of the gross output deflator of the JIP Database 2015 is Japan's GDP

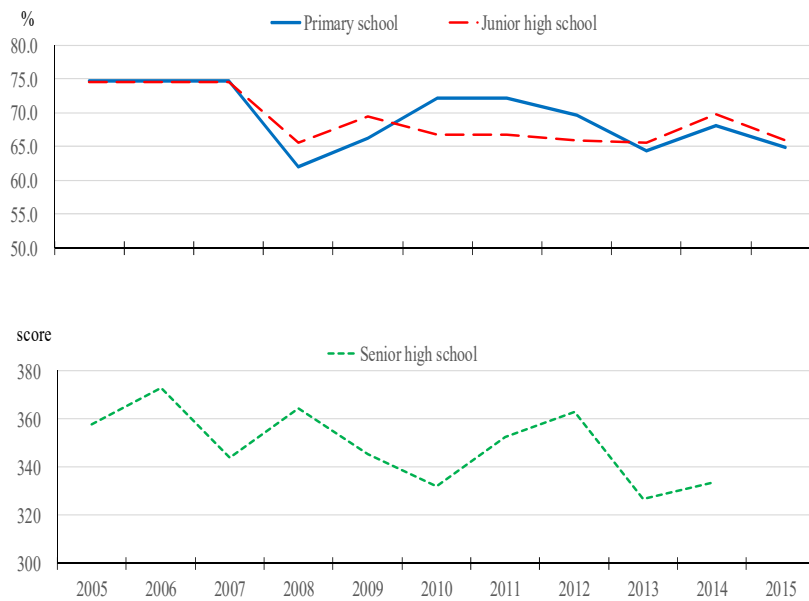
statistics. Reflecting the estimated deterioration in education service quality, our new deflator has increased more than the deflator in the JIP Database.

Figure 15. Number of Students in Japan



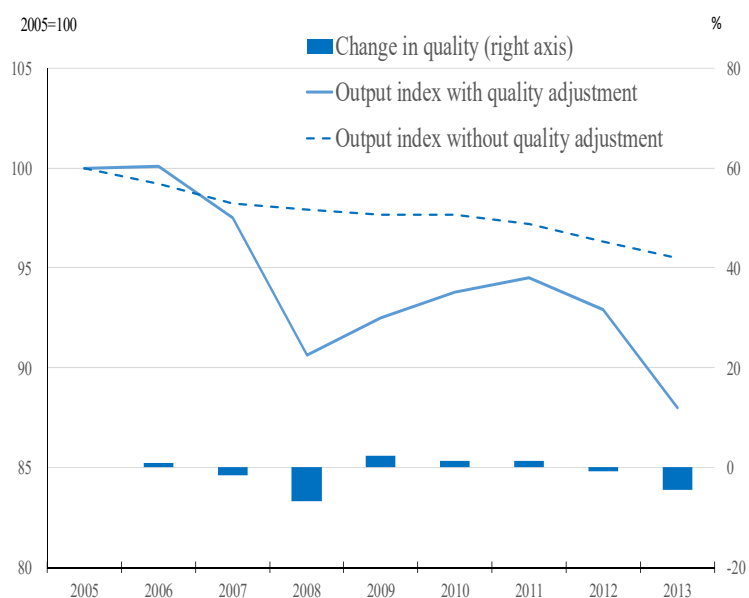
Source: Ministry of Education, Culture, Sports, Science and Technology, *Basic Survey of Schools*.

Figure 16. Test Scores at Primary, Junior, and Senior High School Level in Japan



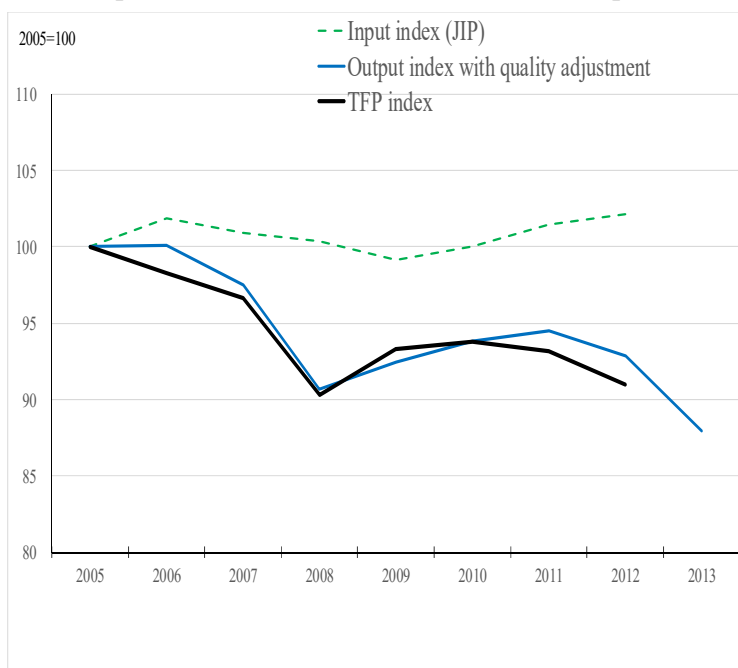
Sources: Ministry of Education, Culture, Sports, Science and Technology, *National Survey of Academic Attainment*, and National Center for University Entrance Examinations, *National Center Test for University Admissions*.

Figure 17. Developments in the Direct Measure of Output with and without Quality Adjustment and the Quality Index: Education Sector, Japan, 2005–13



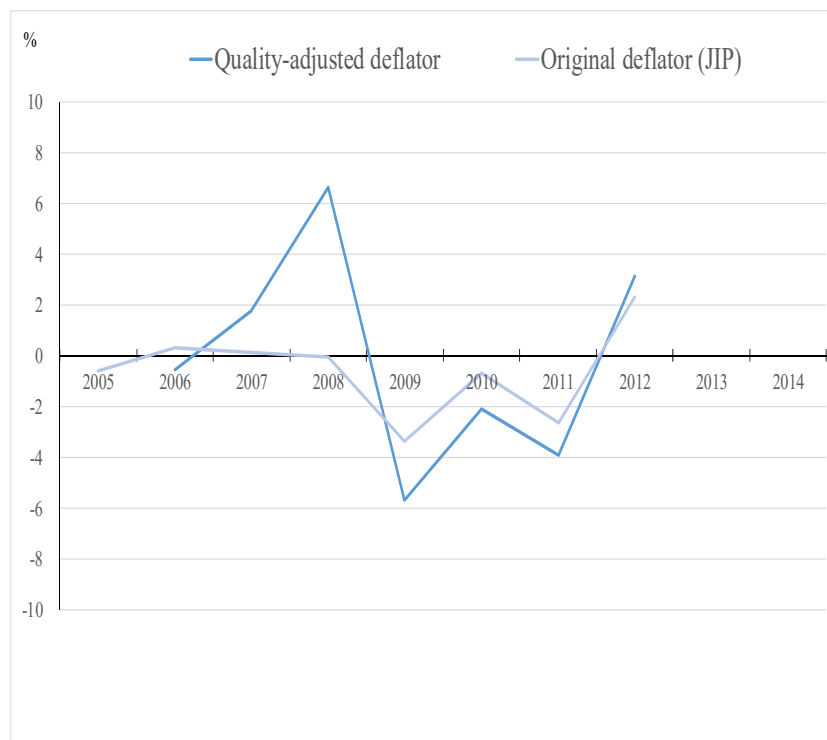
Source: Authors' calculation.

Figure 18. Developments in the Direct Measure of Output with Quality Adjustment, the Total Input Index, and TFP: Education Sector, Japan



Sources: JIP Database 2015 and authors' calculation.

Figure 19. Comparison of Changes in Our New (Implicit) Deflator with Quality Adjustment and the Gross Output Deflator in the JIP Database 2015: Education Sector, Japan



Sources: JIP Database 2015 and authors' calculation.

In the case of Japan's health care sector, we currently face more serious data constraints to measure output quality. For our experimental trial, we use the number of patients as our direct measure of output. Output is first calculated for five-year age groups (0 to 4 years old, 5 to 9 years old, and so on) and then aggregated with health care expenditures for each age group as weights. The number of patients is taken from the *Patient Survey* conducted by the Ministry of Health, Labor and Welfare every three years. For years between surveys, we linearly interpolated patient numbers. Figure 20 shows developments in the number of patients for selected age groups. The number of elderly patients aged 80 to 84 years old steadily increased from 2000 to 2014, while the number of patients in other age groups stagnated or declined.

To measure the quality of medical services, we use the survival rate for each age group in Japan's total population. We obtain the data from the *Abridged Life Table* of the Ministry of Health, Labour and Welfare. While it would be much more desirable to follow the ONS and use information on the survival rate of actual patients and other data such as data from Japan's Diagnosis Procedure Combination (DPC) Database, at present we cannot obtain access to such data. For the time being,

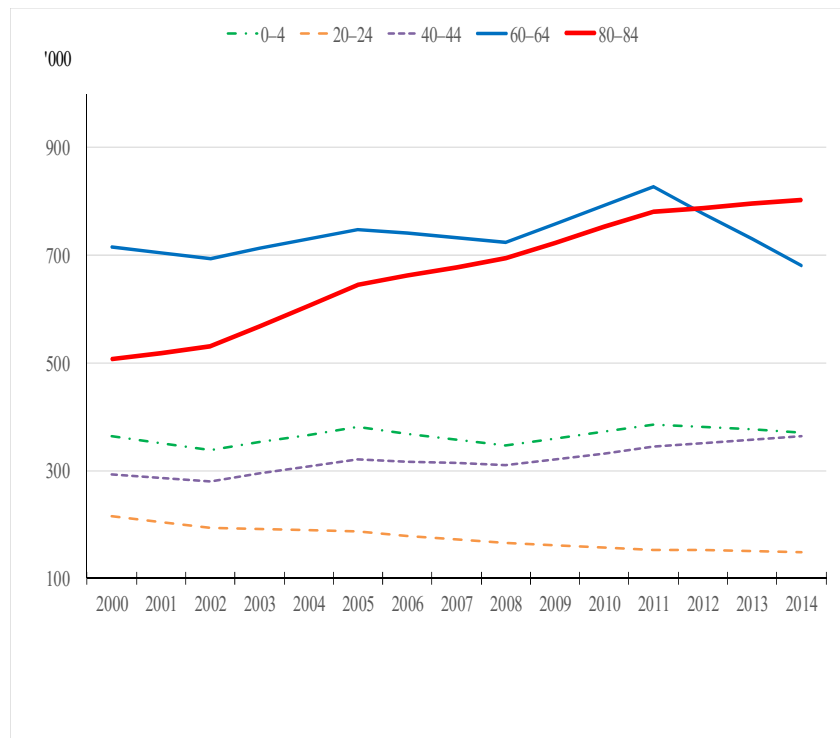
therefore, we use survival rates in the population overall, with survival rates by age group shown in Figure 21. As can be seen, the rate for those aged 80 to 84 is rising, while the rates for other age groups are nearly constant.

Just like for the education sector above, we derive a direct measure of output without quality adjustment, a direct measure of output with quality adjustment, and a quality index using equations (2) and (3). The results are shown in Figure 22. Probably because of the increase in the survival rates of older age groups, the quality index increased over time and the direct measure of output with quality adjustment increased more rapidly than that without quality adjustment.

Again just like for the education sector, we calculate a TFP index by dividing our direct measure of output with quality adjustment by an index of total inputs, which is taken from the JIP Database 2015. Since the input index increased much more quickly than the direct measure of output with quality adjustment, estimated TFP declined by 30% between 2000 and 2012 (Figure 23).

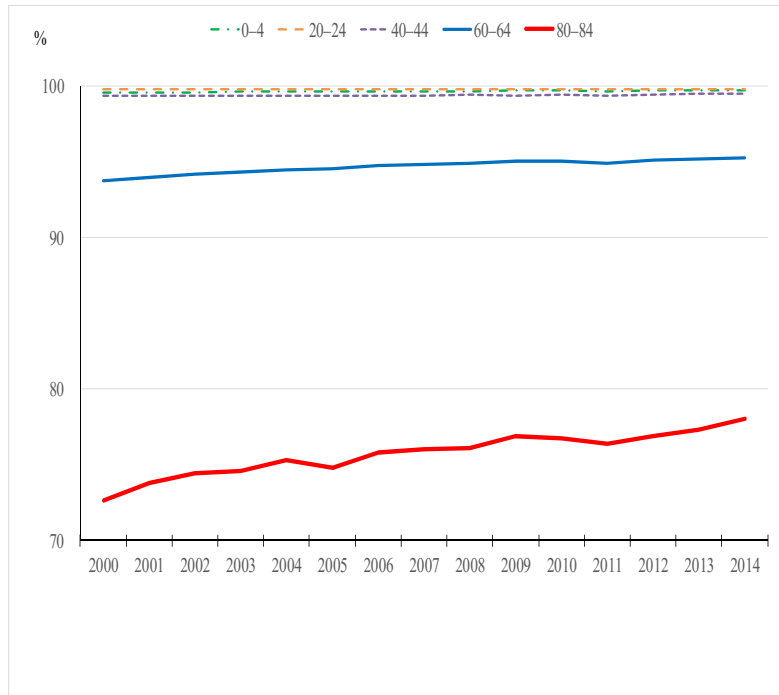
Finally, we derive a new (implicit) deflator with quality adjustment for Japan’s medical services by dividing total gross output of the medical services sector by our new direct measure of output with quality adjustment. Figure 24 compares our new deflator with the gross output deflator in the JIP Database 2015. Because of the very slow and smooth improvement of service quality, the growth rate of the new deflator was slightly lower than that of the deflator in the JIP Database, but the two deflators move in an almost parallel fashion.

Figure 20. Number of Patients by Age Group in Japan



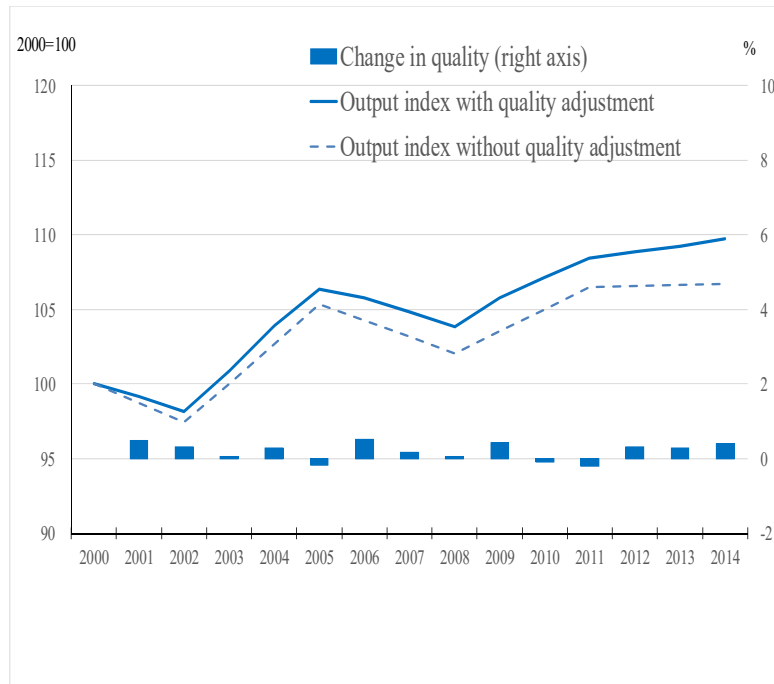
Source: Ministry of Health, Labour and Welfare, *Patient Survey*.

Figure 21. Survival Rate by Age Group in Japan



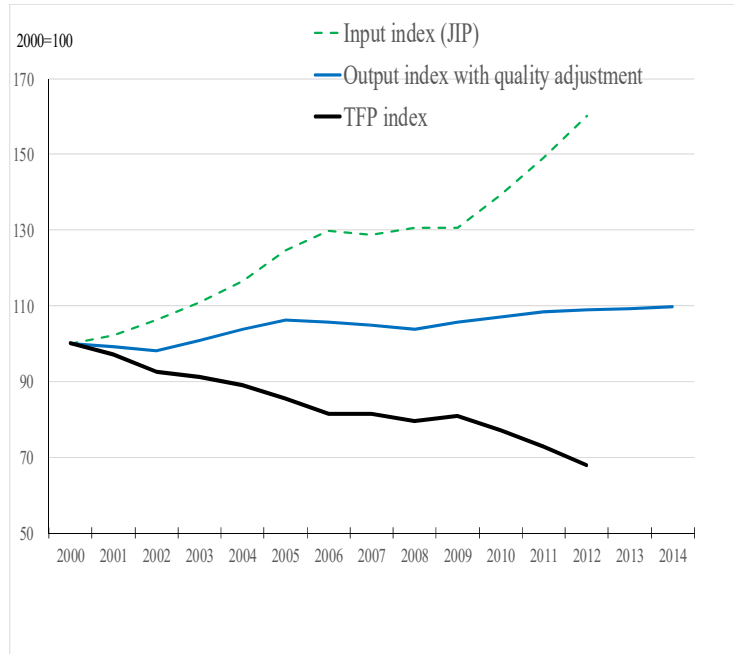
Source: Ministry of Health, Labour and Welfare, *Abridged Life Table*.

Figure 22. Developments in the Direct Measure of Output with and without Quality Adjustment and the Quality Index: Medical Services Sector, Japan



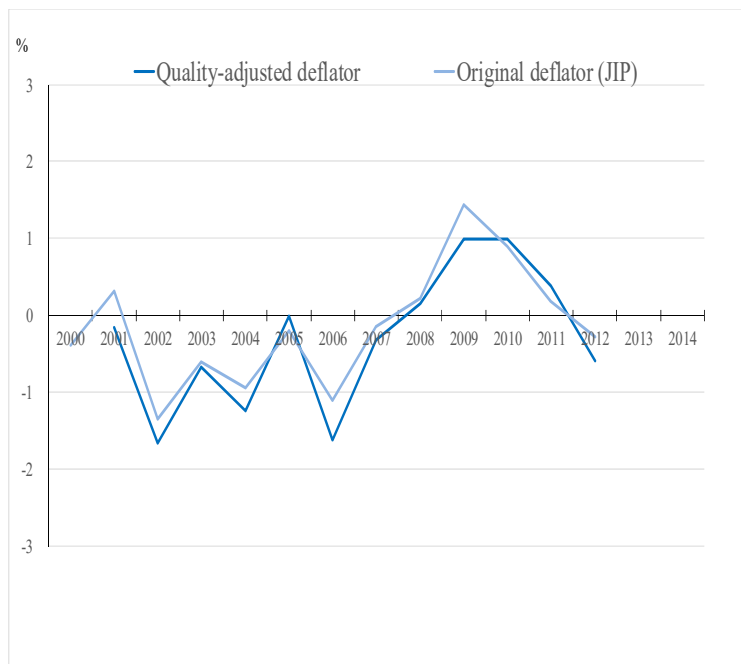
Source: Authors' calculation.

Figure 23. Developments in the Direct Measure of Output with Quality Adjustment, the Total Input Index, and TFP: Medical Services Sector, Japan



Sources: JIP Database 2015 and authors' calculation.

Figure 24. Comparison of Changes in Our New (Implicit) Deflator with Quality Adjustment and the Gross Output Deflator in the JIP Database 2015: Medical Services Sector, Japan



Sources: JIP Database 2015 and authors' calculation.

6. Public Administration and Defense, Compulsory Social Security

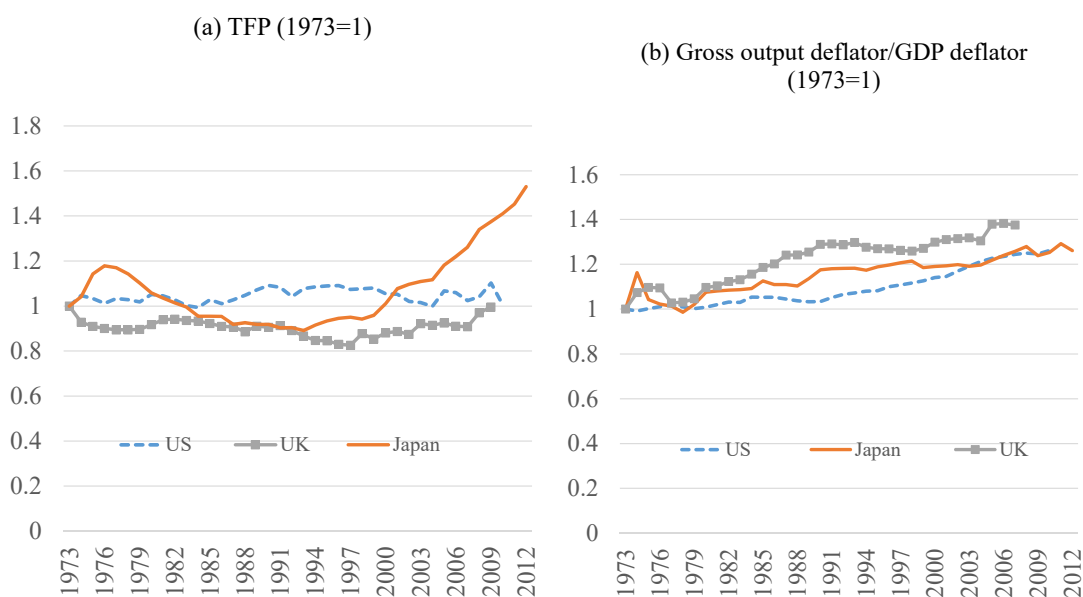
There are also serious measurement problems in the case of public administration and defense, compulsory social security. Just like in the case of public education, both in Japan and the United States, nominal output of most activities in this sector is measured by total input costs, and real output is calculated by deflating nominal output by an input price index which covers intermediate, labor, and capital service inputs (BEA 2015[a], ESRI 2012). Moreover, wages are adjusted for changes in labor quality. Under this output=inputs approach, measured TFP growth will be almost zero.

Figure 25 shows developments in TFP and the gross output deflator for this sector in Japan, the United States, and the UK. Both in the United States and the UK TFP growth in this sector was almost zero when looking at the period as a whole. This result is consistent with our conjecture. In contrast, for Japan, the figure shows rapid increases in TFP from the mid-1990s, which in fact appear too rapid. One reason for the rapid TFP growth in Japan suggested by the figure is that the JIP Database does not take certain types of public capital stock such as public roads and embankments into account and therefore underestimates factor inputs.

As we explained in Section 4, the UK's ONS avoids using factor inputs as a substitute and instead estimates output indexes and GDP statistics using direct measures of output such as the number of national pension members, whose records are processed by the government. In addition to this, the ONS tries to take quality changes into account (ONS 2007).²²

²² Procedures of UK output approach to GDP are also explained in a ONS webpage; <http://www.ons.gov.uk/ons/guide-method/method-quality/specific/economy/output-measure-of-gdp/index.html>

Figure 25. Developments in TFP and the Gross Output Deflator in Public Administration and Defense, Compulsory Social Security: US-UK-Japan Comparison



Sources: World KLEMS Data, EU KLEMS Data, and JIP Database 2015.

6. Conclusion

This paper compared approaches to the measurement of service sector deflators in Japan and other developed countries such as the United States and examined potential impacts of methodological differences on estimates of macroeconomic performances of these countries.

For construction, Japan's deflators for this sector does not take into account the changes in labor quality. According to the JIP Database 2015, during the period 1970-2012, labor quality increased at an annual rate of 0.6%. Hence, Japan's SNA statistics underestimates real GDP growth by 1.7 percentage points for the period 1973-2012 and the JIP Database underestimates TFP growth for the economy as a whole by 1.7 percentage points for the same period.

For wholesale and retail services, margin price per unit would be the appropriate measure of services if the quality of wholesale or retail services does not change over time. While the United States and Canada have started to use margin prices in the calculation of deflators, most other countries including Japan and the United Kingdom still use the prices of commodities as deflators. A recently commenced survey on the margin price per conducted by the Bank of Japan indicates that margin prices for food and beverages, plastics and electric part and devices have increased much less than the PPI for these items. Hence, if measured using margin prices, TFP growth after 2010 would have been higher than that based on the PPI.

For education and health care, we looked at the newly developed output indexes by the ONS of the United Kingdom. Furthermore, we tried to obtain rough estimates of the output and TFP of these sectors in Japan using the direct method and adjusting for quality.

In sum, our analyses shed light on Japan's SNA statistics and indicate rooms for improvement.

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